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## The influence of freshwater runoff on biomass, morphometrics, and production of *Thalassia testudinum*

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### Abstract

Efforts to restore more natural freshwater flows in South Florida will impact Biscayne Bay. In order to evaluate possible effects of decreased freshwater discharge on the seagrass *Thalassia testudinum*, we determined the biomass, density, morphometrics (width, length, number of blades per shoot) and production of *T. testudinum* twice a year for 2 year at sites exposed to varying degrees of freshwater runoff. Responses to freshwater discharge varied between the sampling years. The only morphometric variable to be influenced by freshwater runoff in both years was blade width with width of seagrass blades being less at sites influenced by freshwater runoff than at sites with limited influence of freshwater runoff. In 1996, no other parameters differed among the three freshwater conditions considered; canal discharge, sheet-flow runoff, and limited freshwater runoff. In addition, all measured parameters were greater in summer (wet season) than in winter (dry season) in 1996. In 1997, biomass, shoot weight, shoot production, and areal shoot production all were greater at sites on the eastern side of the bay that experience limited influence from freshwater runoff compared to sites on the western side of the bay that experience large amounts of freshwater runoff from sheet-flow and canal discharge. In 1997, only length of seagrass showed a significant increase from winter to summer. Factors thought to be responsible for these interannual differences are winter temperatures and seasonal rainfall amounts. The winter of 1996 was much colder than the

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winter of 1997, and 1997 experienced an unusually rainy dry season thus increasing the amount of time during the year that freshwater runoff would be influencing sites on the western side of the bay. Based on these results, reduced freshwater inflow to Biscayne Bay should have a positive effect on *T. testudinum* provided detrimental hypersaline conditions do not occur. © 2002 Elsevier Science B.V. All rights reserved.

**Keywords:** Biomass; Freshwater; Salinity; Production; Morphometrics; Seagrass; *Thalassia testudinum*

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## 1. Introduction

The US Army Corps of Engineers installed an extensive drainage control system to alleviate flooding of urban and agricultural areas in south Florida during the 1940s and 1950s (US Army Corps of Engineers, 1999). The levees, canals, and locks greatly altered the natural pattern of freshwater flow in the region. Instead of continuous sheet-flow and runoff into the coastal waters of south Florida, freshwater releases are primarily by point-source discharges of large volumes of water from canal mouths. In Biscayne Bay, FL (a subtropical estuary on the southeast coast of Florida) these discharges produce widely fluctuating and reduced salinity on the western margin of the bay (Wang and Cofer-Shabica, 1988; Cofer-Shabica and Wang, 1990) while the eastern margin of the bay typically experiences high and stable salinity year round (Fig. 1).

The Center for Marine and Environmental Analyses (CMEA) at the University of Miami Rosenstiel School of Marine and Atmospheric Science has been developing a spatially explicit seascape model of Biscayne Bay to evaluate the effects of anthropogenic impacts, including water management, on coastal systems. The seascape model includes several sub-models of major benthic habitats in the bay including hard-bottom sponge communities (Cropper and DiResta, 1999) and seagrasses (see Fong and Harwell, 1994 for an early version of the model). The final seagrass sub-model will predict changes in above-ground biomass over space and time for the three major species of seagrass that occur in the bay (*Thalassia testudinum*, *Halodule wrightii*, and *Syrigodium filiforme*).

In an effort to improve the health of the Everglades system in south FL, the US Army Corps of Engineers is in the process of making changes to the existing canal and drainage system (US Army Corps of Engineers, 1999). The goal of this effort is to increase freshwater flow to the Everglades and Florida Bay. To achieve this, water flow will be diverted from Biscayne Bay to the west. The seascape model being produced by CMEA will provide a management tool aiding in our ability to understand the current Biscayne Bay system and evaluate the potential outcome of proposed changes in freshwater delivery to the bay.

Our present aims were: (1) to establish the condition and performance of *T. testudinum*, the predominant seagrass species in Biscayne Bay, along the freshwater gradient existing before the diversion schedule is operational; and (2) to provide input data for the CMEA seascape model. We present here results of two years of sampling summer/wet and winter/dry periods under the existing freshwater delivery system.

## 2. Methods

### 2.1. Study sites

In 1996, we sampled six sites; two near oceanic inlets that receive little freshwater inflow and have high and stable salinity (Sands Key and Broad Creek), two on the western margin of the bay adjacent to canal discharge sites that experience huge volumes of freshwater input resulting in low and widely fluctuating salinity (Fender Point and Manatee Bay), and two on the western margin of the bay distant from canal discharge but influenced by terrestrial runoff and sheet-flow of freshwater (Barnes Sound and Little Card Sound) (Fig. 1). In 1997, we focused on east (high/stable salinity with little freshwater inflow) and west (low/fluctuating salinity with a lot of freshwater inflow) comparisons. We added two sampling sites on the eastern side of the bay (Virginia Key and Steam Boat Creek) such that we had four sites on the western margin of the bay and four on the eastern margin. All sites were predominantly *T. testudinum*, but some had small amounts of *H. wrightii* present.

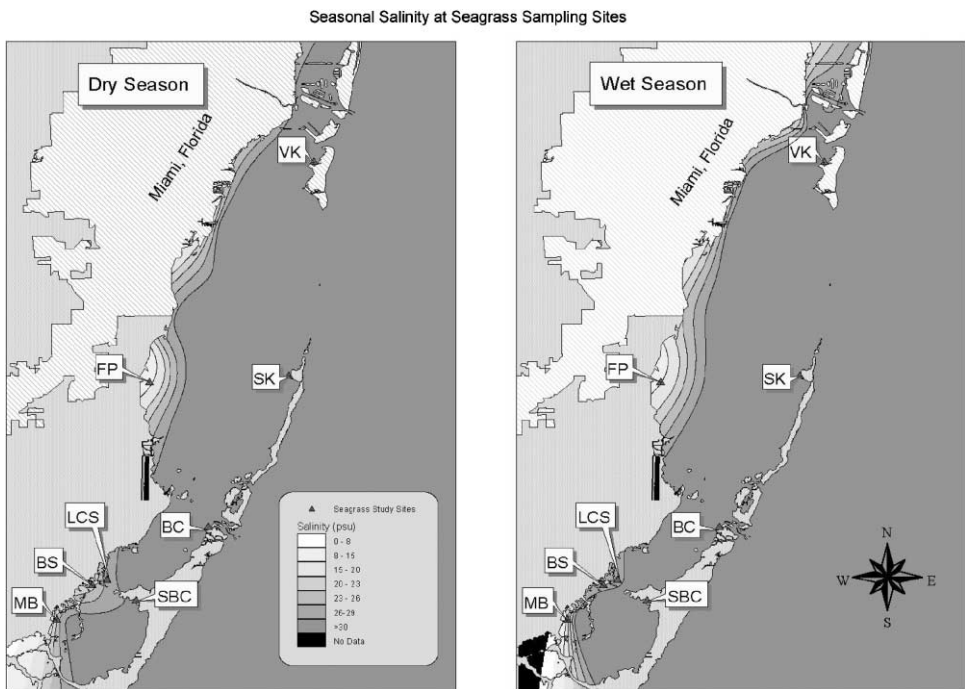


Fig. 1. Seagrass sampling stations and salinity contours in Biscayne Bay, FL in dry (November–April) and wet (May–October) seasons. Contours determined from GIS analysis of salinity data from field sampling, long-term averages of water quality data from the Dade County Department of Environmental Resource Management (Miami, FL), and Dr. John Wang's (The University of Miami) hydrodynamic model. VK: Virginia Key; FP: Fender Point; SK: Sands Key; BC: Broad Creek; LCS: Little Card Sound; BS: Barnes Sound; SBC: Steam Boat Creek; MB: Manatee Bay.

Water depths were similar at the sites and ranged from approximately 0.5–1.0 m. Tidal flow conditions were variable with low (ca. 1 cm/s) and high (ca. 10 cm/s) flows occurring across a range of salinity conditions.

## 2.2. Morphometrics, density, and biomass

During each sampling period, we took twelve cores, 20-cm diameter by 15–30 cm depth, from randomly selected locations at each site. The cores were sieved and rinsed in the field through a 5-mm mesh screen. Samples were then frozen until further processing.

In the lab, we separated *H. wrightii* from *T. testudinum* (if *H. wrightii* was present) and divided material from both species into above-ground live and dead portions. The dead material was not processed further. The total number of live *T. testudinum* shoots was counted from each sample. In a subsample of 10 live shoots (or all shoots if total number <10), we measured leaf length (from point of attachment to the rhizome to tip of intact leaves) and width, and counted the number of leaves per shoot. All material from the samples was then soaked in a dilute HCl acid solution to dissolve any calcareous epiphytes (Ott, 1990), rinsed, and dried to constant weight at 65 °C to get above-ground, live biomass estimates.

## 2.3. Statistical analysis on morphometrics, density, and biomass

Since we were focussing on *T. testudinum*, only cores that had 100% *T. testudinum* were included in any analyses. We averaged measurements across cores and considered the sites as replicates for the different levels of freshwater influence. This approach was taken due to large variances within sites for some of the variables. By using the calculated means for each site the error variances for all variables, except density of *T. testudinum* shoots in 1997, were homogeneous ( $F_{\max}, \alpha = 0.05$ ). Shoot density in 1997 was square-root transformed to homogenize error variances prior to analysis. We used Statistica<sup>TM</sup> statistical analysis software to analyze the data. In 1996, we conducted separate analyses using a model I ANOVA with sampling time (fixed-winter/dry and summer/wet) and freshwater influence (fixed-low runoff near inlets, sheet-flow runoff, and canal discharge sites) as the independent variables and width, length, density, biomass, shoot weight, and number of leaves per shoot as the dependent variables. In 1997, we considered only two levels of freshwater influence (high/west side of the bay and low/east side of the bay) and sampling time as the independent variables.

## 2.4. Productivity

Productivity of *T. testudinum* was measured in the winter and summer of 1997 at all eight sites where density and biomass samples were collected. Ten *T. testudinum* shoots were marked for growth at each site during both seasons by inserting a threaded needle into the shoot just above the sheath (Dennison, 1990). A marker buoy was placed near the marked shoot to aid in relocation. After 7–10 day, the marked plants were retrieved and rinsed in freshwater. The leaf material was separated into old production (that above the mark made

by needle insertion) and new production (that from new shoots and beneath the mark on old shoots). Shoot production was determined by dividing the dry weight of the new leaf production by the time interval, and areal production estimates were made by multiplying shoot production by the estimated shoot density  $\text{m}^{-2}$  (see before) (Dennison, 1990). The average shoot and areal production estimates for each site in each season were analyzed as the dependent variables in separate model I, two-way ANOVAs with season and freshwater influence as the independent variables. Cell means were tested for homoscedasticity of error variances prior to analyses and were found to be homogeneous ( $F_{\max}$ ,  $\alpha = 0.05$ ).

### 3. Results

#### 3.1. 1996—morphometrics, density, and biomass

In 1996, the only measured parameter that showed any response to freshwater runoff was leaf width (Table 1a). Shoots collected from high salinity sites near oceanic inlets that experience limited influence from freshwater runoff were nearly 80% wider than those collected from sites adjacent to canals, and ca. 60% wider than those collected from low salinity sheet-flow sites not adjacent to canals (Table 4). There was also a significant difference in blade widths between summer/wet and winter/dry sampling periods (Table 1a) with blade widths increasing roughly 0.8 mm from winter to summer (Table 3). Shoots were ca. 10 cm longer in the summer sampling period than in the winter (Table 1b). There was no effect of freshwater runoff on the number of blades per shoot (Table 1c), but there was a significant increase of ca. 0.7 blades per shoot from winter to summer sampling (Table 3). Analysis of density and biomass estimates both produced significant differences between summer/wet and winter/dry sampling periods, but no effect of exposure to freshwater runoff (Table 1d and e). Both shoot density and biomass were greater in summer than in winter (Table 3). The shoot weight also differed significantly between the two sampling periods (Table 1f), nearly doubling from winter to summer corresponding to the increase in leaf length, blade width, and number of blades per shoot in the summer sampling period (Table 3).

#### 3.2. 1997—morphometrics, density, and biomass

In 1997, blade width and number of blades per shoot differed between sites experiencing high (west side of bay) and low (east side of bay) amounts of freshwater runoff (Table 2a and c). Blade widths were ca. 2 mm wider from high salinity sites on the eastern side of the bay than from the fresher sites on the western side (Table 4). There were significantly more blades per shoot (0.4) at sites experiencing little freshwater runoff (Table 2c). As in 1996, there was a significant difference between summer/wet and winter/dry sampling periods in blade length (Table 2b) with lengths increasing by ca. 4.0 cm from winter to summer sampling (Table 3). In 1997, density of *T. testudinum* did not vary among sampling periods or with the amount of freshwater runoff (Table 2d, Tables 3 and 4). Biomass of *T. testudinum* was significantly greater at stations that were not influenced by runoff, but did not differ between winter/dry and summer/wet sampling times (Table 2e, Tables 3 and 4).

Table 1  
Results from separate analyses on 1996 sample data from Biscayne Bay, FL using a model I ANOVA with sample time (fixed-winter/dry and summer/wet) and freshwater influence (fixed-limited freshwater influence at Broad Creek and Sands Key, high influence of sheet-flow runoff at Barnes Sound and Little Card Sound, and high influence canal sites at Fender Point and Manatee Bay) as the independent variables<sup>a</sup>

Factor	df	(a) Leaf width (cm)		(b) Shoot length (cm)		(c) Number of blades per shoot		(d) Density (shoots m <sup>-2</sup> )		(e) Biomass (g m <sup>-2</sup> )		(f) Shoot weight (g per shoot)	
		Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>
Sample time	1	0.065	<b>0.0002</b>	0.58	<b>0.025</b>	0.78	<b>0.001</b>	0.45	<b>0.030</b>	0.71	<b>0.005</b>	0.54	<b>0.012</b>
Freshwater	2	0.92	<b>0.000</b>	0.026	0.827	0.064	0.337	0.19	0.268	0.065	0.461	0.18	0.205
Time* Freshwater	2	0.0054	0.145	0.0028	0.979	0.010	0.815	0.022	0.827	0.0063	0.918	0.025	0.760
Error	6	0.006		0.39		0.15		0.34		0.22		0.26	

<sup>a</sup> Data averaged over 10 replicate cores from each site. Degrees of freedom (df), variance explained by each term in the model (ratio of factor sums of squares to total sums of squares), and *P* values are given. Significant *P* values are indicated in bold.

Table 2  
Results from separate analyses on 1997 sample data from Biscayne Bay, FL using a model I ANOVA with sample time (fixed-winter/dry and summer/wet), and freshwater influence (fixed-low freshwater influence on the east side of the bay at Broad Creek, Sands Key, West Point, and Steamboat Creek, and high freshwater influence on the west side of the bay at Manatee Bay, Little Card Sound, Barnes Sound, and Fender Point) as the independent variables<sup>a</sup>

Factor	df	(a) Leaf width (cm)		(b) Shoot length (cm)		(c) Number of blades per shoot		(d) Density (shoot m <sup>-2</sup> )		(e) Biomass (g m <sup>-2</sup> )		(f) Shoot weight (g per shoot)		(g) Leaf production (mg per shoot per day)		(h) Areal Production (g m <sup>-2</sup> per day)	
		Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>	Variance explained	<i>P</i>
Sample time	1	0.020	0.258	0.34	<b>0.020</b>	0.13	0.132	0.033	0.527	0.0028	0.827	0.081	0.156	0.065	0.119	0.036	0.265
Freshwater	1	0.81	<b>0.000</b>	0.080	0.221	0.29	<b>0.031</b>	0.0073	0.764	0.32	<b>0.033</b>	0.49	<b>0.003</b>	0.65	<b>0.000</b>	0.63	<b>0.000</b>
Time*	1	3.9E05	0.959	0.0076	0.697	7.85E05	0.969	0.036	0.506	0.010	0.676	0.0045	0.728	0.0067	0.601	0.016	0.448
Freshwater Error	12	0.17		0.57		0.58		0.92		0.66		0.42		0.28		0.32	

<sup>a</sup> Data averaged over 12 replicate cores. Degrees of freedom (df), variance explained by each term in the model (ratio of factor sums of squares to total sums of squares) and *P* values are given. Significant *P* values are indicated in bold.

Table 3

Mean ( $\pm$ S.E.) for measured parameters in winter/dry and summer/wet sampling periods averaged over all sampled sites in Biscayne Bay, FL<sup>a</sup>

Parameter	1996		1997	
	Winter/dry	Summer/wet	Winter/dry	Summer/wet
Width (cm)	5.2 (0.7)*	5.9 (0.6)**	5.6 (0.5)	5.9 (0.4)
Length (cm)	16.5 (1.9)*	26.4 (1.9)**	20.8 (1.1)*	24.9 (1.04)**
Number of blades per shoot	2.3 (0.1)*	3.0 (0.04)**	2.7 (0.1)	2.9 (0.1)
Density (shoots m <sup>-2</sup> )	479.2 (81.0)*	888.6 (117.9)**	821.3 (119.4)	721.9 (50.3)
Biomass (g m <sup>-2</sup> )	200.7 (30.4)*	606.5 (76.3)**	358.5 (50.0)	371.2 (41.1)
Shoot weight (g per shoot)	0.4 (0.07)*	0.7 (0.05)**	0.5 (0.05)	0.5 (0.06)
Leaf production (mg per shoot per day)	Not measured	Not measured	2.1 (0.4)	2.7 (0.5)
Areal production (g m <sup>-2</sup> per day)	Not measured	Not measured	1.8 (0.4)	2.2 (0.4)

<sup>a</sup> Asterisks indicate significant differences between time periods for any given parameter. ANOVA results are presented in Tables 1 and 2. Six sites for 1996 (Broad Creek, Sands Key, Little Card Sound, Barnes Sound, Fender Point, and Manatee Bay) and eight for 1997 (Steam Boat Creek and West Point added) with 10 and 12 replicate cores, respectively, collected from each site in each time period.

Table 4

Mean ( $\pm$  S.E.) for measured parameters for the different levels of freshwater influences considered in 1996 and 1997 sampling of seagrass beds in Biscayne Bay, FL<sup>a</sup>

Parameter	1996			1997	
	Canal influence	Sheet-flow Influence	Limited freshwater influence	High freshwater influence	Low freshwater influence
Width (cm)	4.2 (0.3)*	4.8 (0.2)**	7.5 (0.2)***	4.6 (0.1)*	6.8 (0.3)**
Length (cm)	20.0 (3.8)	21.6 (4.4)	22.7 (2.8)	21.9 (1.3)	23.9 (1.2)
Number of blades per shoot	2.7 (0.3)	2.5 (0.3)	2.8 (0.2)	3.0 (0.1)**	2.6 (0.1)*
Density (shoots m <sup>-2</sup> )	581.3 (222.7)	870.3 (107.3)	600.2 (120.5)	803.7 (126.1)	739.6 (36.0)
Biomass (g m <sup>-2</sup> )	317.3 (139.6)	453.8 (147.9)	439.8 (113.6)	295.9 (41.3)*	433.8 (33.8)**
Shoot weight (g shoot <sup>-1</sup> )	0.6 (0.1)	0.5 (0.1)	0.7 (0.07)	0.4 (0.04)*	0.6 (0.04)**
Shoot production (mg shoot <sup>-1</sup> per day)	Not measured	Not measured	Not measured	1.4 (0.2)*	3.4 (0.4)**
Areal production (g m <sup>-2</sup> per day)	Not measured	Not measured	Not measured	1.1 (0.2)*	2.9 (0.3)**

<sup>a</sup> Asterisks indicate significant differences among or between freshwater conditions for any given parameter. ANOVA results presented in Tables 1 and 2. Two sites for each salinity category in 1996 (limited freshwater influence at Broad Creek and Sands Key, sheet-flow runoff influence at Barnes Sound and Little Card Sound, and high influence canal sites at Fender Point and Manatee Bay and four sites for each salinity category in 1997 (low freshwater influence at Broad Creek, Sands Key, West Point, and Steam Boat Creek and high freshwater influence at Manatee Bay, Little Card Sound, Barnes Sound, and Fender Point) with 10 and 12 replicate cores, respectively, collected each year from each site.



There was a significant difference in shoot weight between high and low freshwater runoff conditions (Table 2f). Shoot weight increased by 50% from the west to the east side of the bay indicating a greater biomass per shoot for *T. testudinum* at sites experiencing limited freshwater influence (Table 4).

### 3.3. Productivity

Individual shoot production varied significantly with the amount of freshwater runoff, but did not differ between sampling periods in 1997 (Table 2g, Tables 3 and 4). The average shoot production rate for sites on the western margin of the bay that experience freshwater runoff was less than half that of the sites on the eastern margin of the bay (Table 4).

There was also a significant effect of freshwater runoff on areal production (Table 2h). Estimates of areal production at sites experiencing limited freshwater influence (east side of bay) were more than double that at sites on the western side of the bay that are influenced by freshwater runoff (Table 4). No significant difference in areal production was detected between summer and winter time periods (Table 2h and Table 3).

## 4. Discussion

### 4.1. Freshwater influence on patterns in plant characteristics and production

Measurements of plant characteristics made in 1997 demonstrated more significant effects of freshwater discharge than those made in 1996. Prolonged exposure to freshwater discharge, the potential increase in power caused by increasing the number of sites, and analyzing the data using an east (low freshwater influence)–west (high freshwater influence) comparison contributed to the increased number of significant effects of freshwater on the measured variables between years. The only morphometric variable to be influenced by freshwater runoff in both years was blade width with 81–92% of the variation explained by that factor in the ANOVAs (Tables 1 and 2). The width of seagrass blades was less at sites influenced by freshwater runoff than at sites with limited influence of freshwater runoff. This is consistent with other studies that have demonstrated reduced blade widths of *T. testudinum* plants stressed by low salinity (optimum reported salinity for *T. testudinum* ca. 30–40 psu Phillips, 1960; Moore, 1963; Zieman, 1975a; Zieman, 1975b; Zieman, 1982) and high turbidity, low light conditions that may be associated with freshwater runoff (McMillan, 1978; Durako and Moffler, 1981; Phillips and Lewis, 1983; Lee and Dunton, 1997). In 1996, no other parameters differed among the three freshwater conditions considered (Tables 1 and 4).

In 1997, biomass  $\text{m}^{-2}$ , shoot weight, shoot production and areal production all were greater at sites on the eastern side of the bay with limited freshwater influence compared to sites on the western side of the bay that experience freshwater runoff from sheet-flow and canal discharge (Tables 2 and 4). Roughly 30 and 50% of the total variation in biomass  $\text{m}^{-2}$  and shoot weight, respectively, in the ANOVA could be attributed to the independent variable of freshwater (Table 2). Biomass estimates ranged from ca. 250–550  $\text{g m}^{-2}$  and

were similar to values reported for *T. testudinum* from other areas (Zieman, 1975a; Dawes et al., 1985; Lee and Dunton, 1996; Van Tussenbroek, 1998). Approximately 60–65% of the variation in production estimates could be attributed to the freshwater independent variable in the ANOVAs (Table 2). Areal shoot production estimates ranged from 0.5 to 4.2 g m<sup>-2</sup> per day, and were within the range of other published studies as well (Zieman, 1975a; Zieman, 1975b; Zieman et al., 1989; Lee and Dunton, 1996). Our results are consistent with other studies demonstrating that reduced salinity or increased turbidity associated with freshwater runoff can reduce seagrass growth and production (e.g. Zieman, 1975b; Dawes et al., 1985; Kerr and Strother, 1985; Walker, 1985; Walker and McComb, 1990; Fourqurean and Zieman, 1991; Czerny and Dunton, 1995; Lee and Dunton, 1997).

The number of blades per shoot showed a reverse pattern with a greater number of blades per shoot detected at sites influenced by large volumes of freshwater (Table 4). The actual difference in the estimated number of blades per shoot with high and low freshwater influence, however, was less than 0.5 blade, and may have little biological significance.

#### 4.2. Temporal variation in plant characteristics

The 1996 sampling effort indicated that all measured parameters were greater in summer than in winter (Tables 1 and 3). These temporal patterns are similar to other studies that have demonstrated increases in shoot density, number of blades per shoot, leaf length, and biomass for *T. testudinum* from winter to summer (Zieman, 1975b; Macauley et al., 1988; Lee and Dunton, 1996; Van Tussenbroek, 1998). In 1997, temporal differences were much less pronounced with only length of seagrass showing a significant increase from winter to summer (Tables 2 and 3). No other morphometric characteristics or production estimates showed any temporal variation (Table 2). Studies done by Zieman (1975b), however, in the late 1960s and early 1970s in Biscayne Bay demonstrated seasonal differences in productivity with a peak occurring in late spring-early summer and almost no production occurring in the winter when temperatures were low (slightly <20 °C).

The dissimilar temporal responses in plant characteristics between 1996 and 1997 and lack of a difference in productivity between winter and summer in 1997 may have been due to seasonal differences in temperature between the 2 years. The winter of 1996 was colder than that of 1997 with average temperatures in January and February (the coldest winter months) of 19.2 °C ± 0.27 in 1996 versus 21.7 °C ± 1.5 S.E. in 1997 (temperature data for weather stations in Miami-Dade area obtained from the US National Climate Data Center). The colder winter in 1996 may have influenced plant characteristics to produce stronger seasonal differences while the milder winter of 1997 diminished any potential seasonal differences in plant characteristics and productivity estimates.

The increased influence of freshwater delivery in 1997 may be due to differences in rainfall amounts between the 2 years. In 1997, the dry season (November–March) experienced nearly twice the amount of rainfall as it did in 1996 (1996, 40 mm ± 9 S.E. versus 1997, 78 mm ± 22 S.E.) while rainfall amounts during the wet season (April–October) were similar between the 2 years (1996, 203 mm ± 27 S.E. versus 1997, 218 mm ± 52 S.E.) (precipitation data for weather stations in Miami-Dade area obtained from the US National Climate Data Center). The increase in dry-season rainfall amounts in 1997 compared to 1996 contributed to increased freshwater influence during the dry-season on the western margin of the bay.

Modeled estimates of salinity (daily time step), as an indicator of exposure to freshwater influence, for the wet and dry-seasons of 1996 and 1997 (calculated using precipitation data) showed that the salinity near canal discharge sites on the western side of the bay during the dry-season (November–March) was on average nearly 5 psu lower in 1997 than in 1996 ( $17 \text{ psu} \pm 1 \text{ S.E.}$  versus  $22 \text{ psu} \pm 2 \text{ S.E.}$ , respectively) while wet season averages were similar between years (personal communication, John Wang, The University of Miami). In fact, the dry-season salinity was lower than the wet season salinity near canal discharge sites on the western margin of the bay in 1997 ( $17 \text{ psu} \pm 1 \text{ S.E.}$  versus  $21 \text{ psu} \pm 3 \text{ S.E.}$ ).

Freshwater runoff alters the salinity of coastal waters and can influence seagrasses. Long-term monitoring and models of salinity fluctuations in the bay indicate differing degrees of freshwater influence from the west to the east side of the bay (see Fig. 1). Temporal variability in temperature and rainfall appeared to have had an influence over plant morphometrics and production in our study. Our data suggest that freshwater runoff only affects biomass and morphometry of *T. testudinum* in years with particularly high amounts of rainfall and prolonged exposure to low salinity. Based on these results, reduced freshwater inflow to Biscayne Bay with the diversion of freshwater to the Everglades system should have a positive effect on *T. testudinum* provided detrimental hypersaline conditions do not occur (Zieman et al., 1999).

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